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EVALUATION OF POTENTIAL GROUNDWATER PROTECTION STANDARD EXCEEDANCES

NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS

DRAFT

RAMBOLL Bright ideas. Sustainable change.

EVALUATION OF POTENTIAL GROUNDWATER PROTECTION STANDARD EXCEEDANCES VERMILION POWER PLANT NEW EAST ASH POND

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CONTENTS

FIGURES (WITHIN TEXT)

FIGURES (ATTACHED)

ACRONYMS AND ABBREVIATIONS

§	section
35 I.A.C.	Title 35 of the Illinois Administrative Code
BCU	Bedrock Confining Unit
bgs	below ground surface
CCR	coal combustion residuals
DMG	Dynegy Midwest Generation, LLC
GMP	Groundwater Monitoring Plan
GWPS	groundwater protection standard
HCR	Hydrogeologic Site Characterization Report
ID	identification
IEPA	Illinois Environmental Protection Agency
ISGS	Illinois State Geological Survey
IQR	interquartile range
Kelron	Kelron Environmental
LOE	line(s) of evidence
mg/L	milligrams per liter
Middle Fork	Middle Fork of the Vermilion River
NAVD88	North American Vertical Datum of 1988
NEAP	New East Ash Pond
NID	National Inventory of Dams
No.	number
NPDES	National Pollutant Discharge Elimination System
Part 845	35 I.A.C. § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
SSL	statistically significant level
TDS	total dissolved solids
UCU	Upper Confining Unit
USGS	United States Geological Survey
UU	Upper Unit
VPP	Vermilion Power Plant

1. INTRODUCTION

Dynegy Midwest Generation, LLC (DMG) formerly operated the Vermilion Power Plant (VPP) located in Oakwood, Vermilion County, Illinois. The New East Ash Pond (NEAP; Vistra Identification [ID] Number [No.] 912, Illinois Environmental Protection Agency [IEPA] ID No. W1838000002-04, and National Inventory of Dams [NID] No. IL50291) is an inactive, unlined coal combustion residuals (CCR) surface impoundment (SI) that was used to manage CCR and non-CCR waste streams and to clarify process water prior to discharge in accordance with the plant's National Pollutant Discharge Elimination System (NPDES) permit (IL0004057) at the VPP. The NEAP is regulated under Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) (IEPA, 2021).

DMG has submitted an Operating Permit application for the NEAP as required under 35 I.A.C. § 845.230. In October 2021, Ramboll Americas Engineering Solutions, Inc. (Ramboll) identified potential GWPS exceedances for chloride, lithium, sulfate, and total dissolved solids (TDS) in groundwater samples collected from monitoring wells in the vicinity of the NEAP, as presented in the Operating Permit application. This report was developed to further evaluate the potential GWPS exceedances identified.

1.1 New East Ash Pond Design

The NEAP is a 29-acre inactive, unlined CCR SI constructed overtop a thick shale formation using berms constructed with a low-permeability clay core and cutoff walls keyed into the underlying shale formation.

The original East Ash Pond (1989 pond footprint) was constructed in 1989 and expanded in 2002 to form the present-day NEAP. The 1989 pond footprint was built overtop a thick shale formation which is greater than 80 feet thick in the vicinity of the ash ponds. The earthen berms on the north, east, and south sides of the 1989 pond footprint were constructed with a low-permeability clay core and cutoff walls keyed into the underlying shale formation. The cutoff walls extended approximately 8 feet into the underlying shale. A natural earthen bluff composed of low-permeability native clays formed the west side of the 1989 pond footprint.

New berms were constructed to expand the capacity of the 1989 pond footprint in 2002, forming the footprint of the present-day NEAP. The new berms raised the height of the original berms and were constructed with clay liners keyed into the underlying clay core. A cutoff trench backfilled with low permeability fill was placed along the western side slope of the enlarged NEAP. The low-permeability materials surrounding the footprint of the present-day NEAP form the existing containment system. The secondary pond was not expanded or modified as part of the 2002 NEAP expansion. The VPP ceased operations in 2011 when the power plant was retired.

2. BACKGROUND

2.1 Site Location and Description

The former VPP is located four miles northeast of the Village of Oakwood in Vermilion County (**Figure 1**). The NEAP lies in the bottomlands of the Middle Fork of the Vermilion River (Middle Fork) and is bordered to the west by bluffs, to the south by unimproved DMG land, and to the north and east by the Middle Fork. Several underground coal mines and one surface mine were historically operated both beneath the NEAP and in the vicinity of the VPP.

2.2 Geology and Hydrogeology

The VPP geologic and hydrogeologic setting summarized below is excerpted from the Hydrogeologic Site Characterization Report (HCR) for the NEAP (Ramboll, 2021a).

There are three principal types of unlithified materials above bedrock in the vicinity of the NEAP, including the following: fill and CCR (CCR consisting primarily of fly ash with lesser amounts of bottom ash and slag), mixed alluvial deposits of the Cahokia Alluvium (composed primarily of sand with occasional layers of silty clay), and the Upper Till Unit (Wedron Formation till, including diamicton, consisting of clay and silty clay with occasional sand lenses).

In the vicinity of the VPP, the principal bedrock formation is the Shelburn Formation, which contains a major coal seam mined in the region, the Danville (No. 7) Coal. Groundwater flows from the shale into the overlying alluvium and, in some locations, enters into the Middle Fork. Groundwater within the bedrock is at the end of its flow path as indicated by upward hydraulic gradients, high dissolved mineral content, and isotopic analysis indicating water is significantly older by 13,000 to 35,000 radiocarbon years before present than recent groundwater in the overlying unlithified deposits.

The Quaternary deposits in the vicinity of the VPP consist mainly of mixed deposits of the Cahokia Alluvium and diamictons that were deposited during the Wisconsinan and Illinoian glaciations. The unconsolidated deposits and bedrock which occur at the VPP include the following units (beginning at the ground surface):

- Fill and CCR Unit – Generally 15 to 40 feet thick, CCR consisting primarily of fly ash with lesser amounts of bottom ash and slag confined within the berms of the NEAP.
- Upper Unit (UU) – Generally 10 to 25 feet thick, fine to medium sand of the Cahokia Alluvium that contains silts, clays, and gravels in varying amounts with occasional layers of silty clay.
- Upper Confining Unit (UCU) – Variable thickness. A low permeability till, including diamicton, consisting of clay and silty clay with occasional sand lenses of the Wedron and Glasford Formations. West of the NEAP, the UCU is up to 100 feet thick. The UCU is absent east of the NEAP.
- Bedrock Confining Unit (BCU) – Greater than 80 feet thick. Pennsylvanian-age Shelburn Formation characterized as primarily low permeability shale with thin limestone, sandstone, and coal beds. The Danville (No. 7) Coal, a major coal seam mined in the region, was encountered near the NEAP at depths of 80 to 100 feet below ground surface (bgs).

None of the units described above have been identified as an aquifer as defined by 35 I.A.C. § 610.110; however, the UU and BCU have been identified as potential migration pathways

(Ramboll 2021a). Groundwater elevations at the NEAP were obtained from measurements in BCU monitoring wells on March 29, 2021 prior to a sampling event. Groundwater elevations (referenced to North American Vertical Datum of 1988 [NAVD88]) in the NEAP area ranged from about 569 to 604 feet NAVD88 (**Figure 2**). Potentiometric surface maps generated for the BCU indicate groundwater flow is east to southeast, consistent with previously established flow towards the Middle Fork, and with upward vertical gradients demonstrating that the Middle Fork is the receiving body of water for bedrock groundwater.

2.3 Groundwater and NEAP Monitoring

The proposed Part 845 monitoring well network for the NEAP was established in the Groundwater Monitoring Plan (GMP; Ramboll, 2021b). The proposed monitoring well network consists of monitoring wells installed in the UU, UCU, and BCU, including background monitoring wells 10 and 22, located west of the NEAP, and downgradient monitoring wells 16A, 16B, 35S, 35D, 70S, 70D, 71S and 71D (**Figure 3**). NED1 (installed in CCR) is used to collect porewater samples and monitor water levels within the NEAP.

3. POTENTIAL GROUNDWATER PROTECTION STANDARD EXCEEDANCES REVIEW

An evaluation of the history of potential GWPS exceedances was competed for the Operating Permit application in October 2021 (Ramboll, 2021c). Groundwater concentrations from 2015 to 2021 were evaluated for potential exceedances in accordance with the Statistical Analysis Plan (GMP Appendix A; Ramboll, 2021b) proposed in the Operating Permit application and are summarized below:

- Chloride at monitoring wells 35D and 70D: The chloride statistical results at 35D and 70D are 227 and 591 milligrams per liter (mg/L), respectively, which exceed the Part 845 GWPS (200 mg/L).
- Lithium at monitoring wells 35D and 70D: The lithium statistical results at 35D and 70D are 0.100 and 0.063 mg/L, respectively, which exceed the Part 845 GWPS (0.040 mg/L).
- Sulfate at monitoring wells 35D and 70S: The sulfate statistical results at 35D and 70S are 701 and 586 mg/L, respectively, which exceed the Part 845 GWPS (400 mg/L).
- TDS at monitoring wells 35D and 70D: The TDS statistical results at 35D and 70D are 1,650 and 1,730 mg/L, respectively, which exceed the Part 845 GWPS (1,200 mg/L).

Monitoring wells 35D and 70D are screened within the BCU. Monitoring well 35D is located northeast of the NEAP and monitoring well 70D is located south of the NEAP. 70S is screened within the UU and is located south of the NEAP (**Figure 3**).

4. LINES OF EVIDENCE THAT POTENTIAL GROUNDWATER PROTECTION STANDARD EXCEEDANCES ARE NOT RELATED TO THE NEAP

Review of groundwater and porewater data indicates that the potential GWPS exceedances are not related to the NEAP, as supported by the lines of evidence (LOE) below:

1. The Ionic Composition of Bedrock Groundwater is Different Than the Ionic Composition of Porewater.
2. Concentrations of Chloride in the NEAP are Lower than Those Observed in the Groundwater.
3. Proximity of the NEAP to Historic Coal Mining Activity and Related Groundwater Quality Impacts.
4. Influence of Bedrock Groundwater Quality on Upper Unit Groundwater Due to Upward Vertical Gradients.
5. Sulfate Concentrations at 70S Do Not Exhibit a Strong Correlation with Boron Concentrations.
6. Lithium is Present Within the Bedrock on Site

These LOEs are described and supported in greater detail below.

4.1 LOE #1: The Ionic Composition of Bedrock Groundwater is Different Than the Ionic Composition of Porewater

Piper diagrams graphically represent ionic composition of aqueous solutions. A Piper diagram displays the position of water samples with respect to their major cation and anion content on the two lower triangular portions of the diagram, providing the information which, when combined on the central, diamond-shaped portion of the diagram, identify composition categories or groupings (hydrochemical facies). **Figure A**, below, is a Piper diagram that displays the ionic composition of samples collected from the bedrock background and bedrock compliance wells associated with the NEAP (sampled August 17, 2021), and porewater sampling location associated with the NEAP (sampled August 17, 2021).

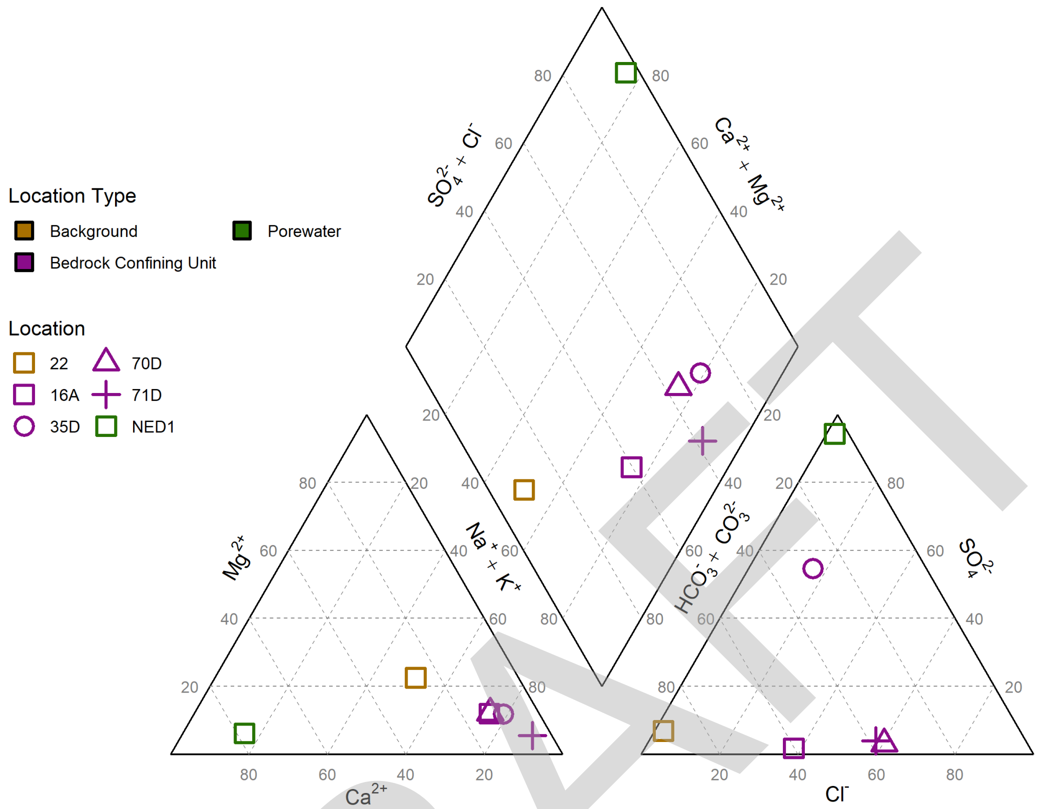

Figure A. Piper Diagram. Shows ionic composition of samples of bedrock groundwater and porewater associated with the NEAP (collected on August 17, 2021).

It is evident from the piper diagram (**Figure A**) that porewater from the NEAP (green symbol) is primarily in the calcium-sulfate hydrochemical facies, while the bedrock groundwater samples (purple symbols) and background sample (brown symbol) are predominantly in the sodium-chloride and sodium-bicarbonate hydrochemical facies. Therefore, the bedrock groundwater samples collected have a different ionic composition than porewater, indicating that NEAP porewater is not the source of CCR constituents detected in wells 35D or 70D.

4.2 LOE #2: Concentrations of Chloride in the NEAP are Lower than Those Observed in the Groundwater

A box plot of chloride concentrations in downgradient monitoring wells 35D and 70D and porewater well NED1 is provided in **Figure B** below. Box plots graphically represent the range of a given dataset using lines to construct a box where the lower line, midline, and upper line of the box represent the values of the first quartile, median, and third quartile values, respectively. The minimum and maximum values of the dataset (excluding outliers) are illustrated by whisker lines extending beyond the first and third quartiles of (*i.e.,* below and above) the box plot. The interquartile range (IQR) is the distance between the first and third quartiles. Outliers (values that are at least 1.5 times the IQR away from the edges of the box) are represented by single points plotted outside of the range of the whiskers.

Chloride concentrations are lower in NEAP porewater samples during 2021 than in downgradient groundwater samples collected from wells 35D and 70D during 2021. The maximum concentration of chloride detected in NEAP porewater (44 mg/L) is lower than the minimum concentration of chloride in 35D (199 mg/L) or 70D (317 mg/L). Porewater chloride concentrations that are lower than groundwater chloride concentrations indicate that NEAP porewater is not the source of chloride detected in wells 35D or 70D.

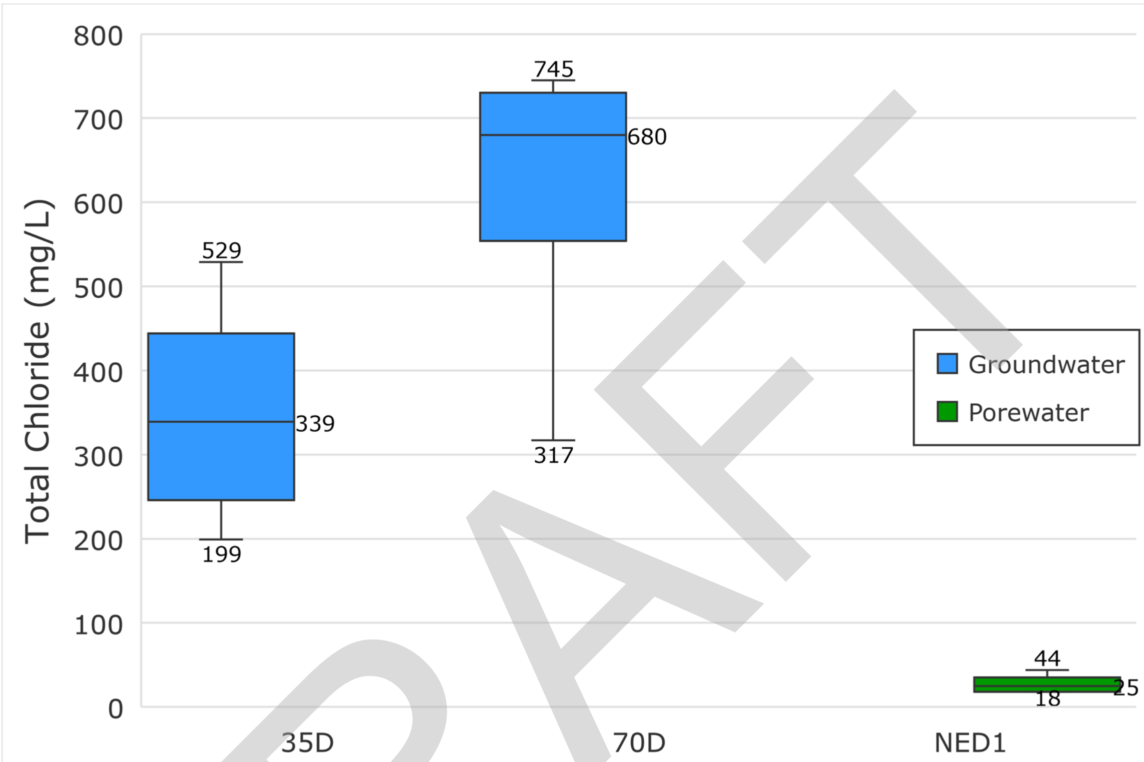

Figure B. Chloride Box Plot. The maximum, median, and minimum values are noted.

4.3 LOE #3: Proximity of the NEAP to Historic Coal Mining Activity and Related Groundwater Quality Impacts

The area under and surrounding the NEAP consists of several underground Danville (No. 7) Coal mines and one surface mine located approximately 740 feet southeast of the NEAP. The extent of the underlying mines, and their associated features, are shown in **Figure 4**. The three mines nearest the NEAP are the Crawford Mine, Middle Fork No. 2 Mine, and Pilot Mine, and are discussed in detail below.

The Crawford Mine (Illinois State Geological Survey [ISGS] Index No. 3889) underlies most of the NEAP. The Crawford Mine is a slope mine with the main coal seam (Danville [No. 7] Coal) located between the depths of 80 and 92 feet bgs. The average thickness of the main coal seam is approximately 5.5 feet (Kelron, 2003). The mine entrance and extent were field verified as discussed in Kelron 2003 and presented in **Figure 4**.

The coal in the vicinity of the NEAP was typically mined from 80 to 100 feet bgs. Groundwater monitoring wells for the NEAP are screened between 10 and 51 feet bgs. Potentiometric data indicate that groundwater flows towards the Middle Fork (**Figure 2**) and vertical gradient data indicate upward vertical gradients within the bedrock and between the bedrock into the overlying unconsolidated materials (Ramboll, 2021a). The compliance monitoring wells are located within approximately 50 to 350 feet of the mine footprints (**Figure 4**).

Illinois groundwater quality regulations (35 I.A.C. § 620 - Groundwater Quality) acknowledge that water quality is adversely affected in areas where coal mining activity has occurred. Class IV groundwater as defined by 35 I.A.C. § 620.240(g) is groundwater within a previously mined area that cannot meet the standards of Class I or II groundwater. The groundwater quality standards for TDS, chloride, iron, manganese, sulfate, and pH within previously mined areas are the existing concentrations of these constituents in groundwater (35 I.A.C. § 620.440). The proximity of the NEAP to historic coal mining activity and the influence of former coal mines, as well as influences from surficial mine spoils, documented on the geochemistry of groundwater in the bedrock at the site (Kelron, 2003; Ramboll, 2021a) demonstrate that historic mining activity has affected groundwater quality in the vicinity of the NEAP, and present an alternative source of potential GWPS exceedances.

4.4 LOE #4: Influence of Bedrock Groundwater Quality on Upper Unit Groundwater Due to Upward Vertical Gradients

ISGS geochemistry of groundwater research (2002) indicates that multiple wells studied at the VPP received water from the bedrock (*i.e.,* upward gradients). Vertical gradients calculated using groundwater elevations during 2002 investigations at the VPP indicate upward vertical gradients between the BCU and UU (Kelron, 2003). Additional earlier investigations reported that upon intercepting fractured shale above the coal mines during coring, the groundwater, which had accumulated within the fractured shale and underlying coal seam and voids, rose to over 30 feet above ground surface, further supporting potentiometric head differences and groundwater movement from the BCU to the UU (Kelron, 2003).

The vertical gradient calculated between wells 35S and 35D during March 2021 was also upward at -0.140 feet per foot (Ramboll, 2021a). The vertical hydraulic gradient could only be calculated in March 2021 because the groundwater elevation at well 35D was either not static or well 35S was dry for the remaining 2021 field investigation monitoring events. Note that well 35D (installed in March 2017) replaced well 13A, where the greatest upward gradients within the bedrock were observed and reported in the 2003 Kelron Report; it is expected that vertical gradients are upward at well nest 35S/35D under normal conditions (static conditions) (Ramboll, 2021a).

Calculated vertical gradients demonstrate groundwater quality from the BCU, which has a high dissolved mineral content (Kelron, 2003), is influencing groundwater quality in the UU as it flows upward; and presents an alternative source of potential GWPS exceedances in the UU.

4.5 LOE #5: Sulfate Concentrations at 70S Do Not Exhibit a Strong Correlation with Boron Concentrations

Boron is a common indicator of CCR impacts to groundwater due to its leachability from CCR and mobility in groundwater. If a CCR constituent is identified as a potential GWPS exceedance, but boron is not correlated with that constituent, it is unlikely that the CCR unit is the source.

Figure C below provides a scatter plot of sulfate versus boron concentrations (collected during 2021) in downgradient groundwater at well 70S along with the results of a Kendall correlation test for non-parametric data. The results of the test are described by the p-value included in the plot. Typically, a p-value less than 0.05 is considered to indicate a statistically significant relationship.

The results of the correlation analysis (**Figure C**) of sulfate concentrations to boron concentrations have a p-value of 0.6, indicating that groundwater concentrations of sulfate observed at monitoring well 70S do not correlate with concentrations of boron. These results indicate the NEAP is not the source of the sulfate detected.

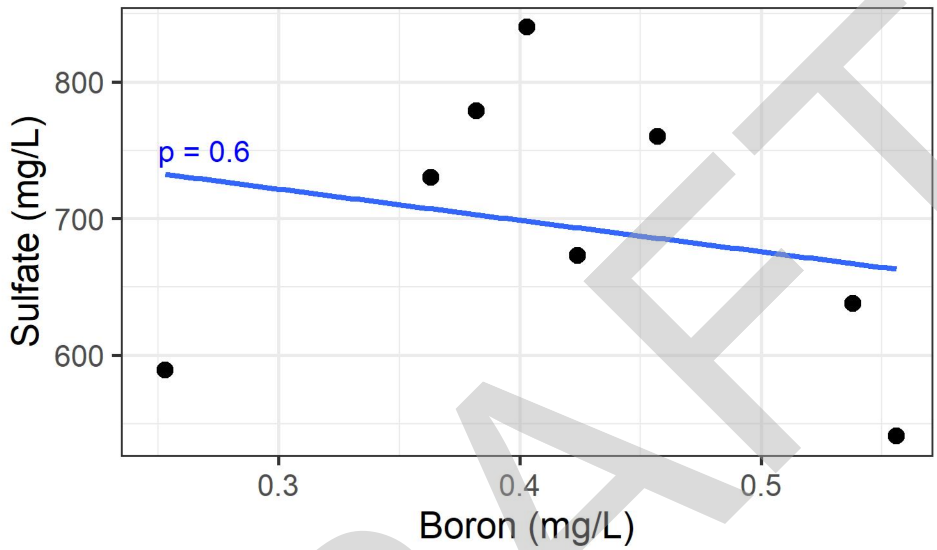

Figure C. Correlation Between Boron and Sulfate Concentrations in Monitoring Well 70S

4.6 LOE #6: Lithium is Present in the Bedrock on Site

Solids analytical sampling was conducted during 2021 investigation activities (Ramboll, 2021a). Bedrock samples from the shale were collected at well locations 70D and 71D. Lithium was identified in the bedrock at concentrations of 33.3 and 31.1 mg/kg, respectively (Table 2-3 of the HCR, Ramboll, 2021a). This is consistent with lithium concentrations, approximately 2 to 30 mg/kg, identified in the Danville (No. 7) Coal (United States Geological Survey [USGS], 2002), and less than the average shale lithium concentration of approximately 60 mg/kg presented in a 2017 USGS resource on lithium (USGS, 2017). Samples of CCR collected from the neighboring North Ash Pond indicated the presence of lithium ranging between 16.2 mg/kg and 60.7 mg/kg (Table 2-2 of the HCR for the North Ash Pond and Old East Ash Pond [Ramboll 2021d]) which is similar to the average shale lithium concentration reported by the USGS and the observed lithium concentrations collected from bedrock on site. The presence of lithium concentrations in shale bedrock at similar concentrations to CCR demonstrates there is an alternative source of the lithium detected.

5. CONCLUSIONS

Based on these six LOEs, it has been demonstrated that the NEAP is not the source of the potential chloride, lithium, sulfate, and TDS GWPS exceedances identified.

1. The Ionic Composition of Bedrock Groundwater is Different Than the Ionic Composition of Porewater.
2. Concentrations of Chloride in the NEAP are Lower than Those Observed in the Groundwater.
3. Proximity of the NEAP to Historic Coal Mining Activity and Related Groundwater Quality Impacts.
4. Influence of Bedrock Groundwater Quality on Upper Unit Groundwater Due to Upward Vertical Gradients.
5. Sulfate Concentrations at Well 70S Do Not Exhibit a Strong Correlation with Boron Concentrations.
6. Lithium is Present within the Bedrock on Site.

6. REFERENCES

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FIGURES

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Vermilion\NEAP\PotGWProtectExc\Figure 1_Site Location Map.mxd

PART 845 REGULATED UNIT (SUBJECT

PROPERTY BOUNDARY

0 1,000 2,000 Feet

DRAFT

SITE LOCATION MAP

EVALUATION OF POTENTIAL GROUNDWATER PROTECTION EXCEEDANCES
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS

FIGURE 1

RAMBOLL AMERICAS
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BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
GROUNDWATER ELEVATION CONTOUR (5-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION
PART 845 REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE
PROPERTY BOUNDARY

NOTES:
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. NM = NOT MEASURED
3. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)
4. * ELEVATION COLLECTED AS PART OF NPDES PERMIT NO. IL0004057 MONITORING ON MARCH 29, 2021.

0 150 300 Feet

BEDROCK GROUNDWATER ELEVATION CONTOURS MARCH 29, 2021

EVALUATION OF POTENTIAL GROUNDWATER PROTECTION EXCEEDANCES
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS

FIGURE 2

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

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Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Vermilion\NEAP\PotGWProtectExc\Figure 2_GWE Contours Event 1_20210329.mxd
PROJECT: 169000XXXX | DATED: 11/1/2021 | DESIGNER: STOLZSD

COMPLIANCE WELL
BACKGROUND WELL
SOURCE SAMPLE LOCATION
PART 845 REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE
PROPERTY BOUNDARY

0 150 300 Feet

SAMPLE LOCATION MAP

EVALUATION OF POTENTIAL GROUNDWATER PROTECTION EXCEEDANCES
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS

FIGURE 3

RAMBOLL AMERICAS
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Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Vermilion\NEAP\PotGWProtectExc\Figure 3_Sample Location Map.mxd

COMPLIANCE
BACKGROUND
SOURCE SAMPLE
COAL MINE SHAFT
UNDERGROUND OR SURFACE COAL MINE
PART 845 REGULATED UNIT (SUBJECT
SITE FEATURE
PROPERTY

0 150 300 Feet

COAL MINE LOCATION MAP

EVALUATION OF POTENTIAL GROUNDWATER PROTECTION EXCEEDANCES
NEW EAST ASH POND
VERMILION POWER PLANT
OAKWOOD, ILLINOIS

FIGURE 4

RAMBOLL AMERICAS
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Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Vermilion\NEAP\PotGWProtectExc\Figure 4_Active and Abandoned Coal Mines.mxd

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